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GRIP STRENGTH: AN ALTERNATIVE FOR MEASURING OSTEOPOROSIS IN ELDERLY

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ABSTRACT

Introduction

The increasing prevalence of osteoporosis has substantial impact on health and economic status of elderly population. The assessment of bone mineral density by dual-energy x-ray absorptiometry (DEXA) scan is inconvenient and not always plausible; especially in the resource-limited settings of developing countries due to various factors like availability, accessibility and affordability. The objective of the study was to assess whether hand grip strength (HGS) measured by a simple hand-held dynamometer could be an alternative tool for screening of osteoporosis in the elderly population.

Method

The study was a cross-sectional, hospital based study conducted on 98 elderly participants (aged with 65 years and above) not having any osteoporotic fracture or symptoms related to musculoskeletal system. The participants were recruited in the geriatric out-patient department of All India Institute of Medical Sciences, New Delhi, India, after written consent. Bone mineral density was evaluated at three sites - at the distal forearm of non-dominant hand, lumbar spine and hip using Dual-energy x-ray Absorptiometry (DEXA). HGS was measured in both the dominant and non-dominant hands using a hand held Gripper Gym Dynamometer. Multivariate Regression analysis was done to find associations and receiver operating characteristic (ROC) analysis was done to find accuracy of grip strength.

Results

Study included 55 (56%) males and 43 (44%) post-menopausal females. The mean age of study participants was 70.22 years. The mean HGS was 18.11 Kg. The mean T-score for spine, hip and forearm were -2.2, -2.18 and -3.4 respectively. Older age is associated with poor HGS (p=0.02). Multivariate regression showed significant association of HGS with loss of bone mineral density in the lumbar spine (p=0.000), hip (p= 0.022) as well as the forearm (p=0.000). ROC analysis showed the area under curve (AUC) for lumbar spine was found to be 0.725 (0.623-0.827), AUC for hip bone 0.724 (0.680-0.869), AUC for forearm bone 0.837 (0.729-.0953) .ROC analysis showed that 83.7% of osteoporosis of forearm bone diagnosed by DEXA has been explained by HGS with area under curve(AUC) 0.837 (0.729-.0953)

Conclusions

In this cohort of elderly, HGS was found to be an useful and independent indicator of general bone density. Also, HGS analysis is a far more practical and cheaper alternative to bone densitometry evaluation by the expensive DEXA machine.

KEYWORDS: Dual-Energy X-Ray Absorptiometry (DEXA), Hand Grip Strength (HGS), Osteoporosis

INTRODUCTION

Osteoporosis, an emerging public health problem, has substantial impact on elderly population due to its morbidity, mortality and economic burden [1] [2]. The prevalence of osteoporosis increases with aging. According to World Health Organization (WHO) up to 70% of women over the age 80 years have osteoporosis [1]. The number of osteoporosis patients in India was approximately 26 million (2003 figures), which was projected to increase to 36 million by 2013.[3]**.** Most grieving complication of osteoporosis is the silent fracture of spine and hip, creates a vicious cycle of immobility, disability, dependency and loss of autonomy, there by compromising overall quality of life. Surprisingly, despite being a well discussed public health concern it is greatly it is vastly under diagnosed and undertreated in Asia, even in the most high risk patients who have already had/developed a fracture already fractured. The problem is particularly more in rural areas.[4]

The recommended method for the diagnosis of osteoporosis is bone mineral density (BMD) measurement by dual-energy X-ray absorptiometry (DEXA) [5]. Bone mineral density with T score that lies 2.5 standard deviations or more below the average value for young healthy women is defined as osteoporosis [5]. But it is not widely practised due to the lack of availability of machines, and low sensitivity though having high specificity [1]. Furthermore in developing countries like India, economic constraints make the usage of DEXA analysis at primary health care setting care setting highly unlikely though burden of osteoporosis is higher in rural area. [4].

So for obvious reason DEXA scans cannot be done universally at all health care levels in developing countries. However, other screening tools like clinical risk factor analysis have been developed to identify those patients with high risk of osteoporosis [6, 7]. Most of these tools consider many factors, making calculation of risk erroneous [8, 9]. A simple tool for screening of osteoporosis is of utmost importance especially in a developing countries like India where the resources are limited and and there is an ever increasing population of elderly individuals.

HGS, an established parameter of physical performance and muscle strength, has been reported to be associated with bone mass locally at the forearm, distant skeletal sites, including the spine and hip.[10] this test that requires little training and only requires a few minutes,

Most studies have assessed HGS as a screening objective parameter to predict fractures, probably independent of BMD [10]. It is questionable that the presence of fractures may lead to physical disability and hence reduced muscle mass and strength. [11]. Furthermore the validity of HGS has not been documented in developing countries [12]. Our primary objective was to assess whether poor HGS can be a simpler alternative to DEXA scan in screening osteoporosis/osteopenia in asymptomatic elderly Indian population. Secondary objective was to find out the association of various factors like socioeconomic status, nutrition, Vit D with osteoporosis in developing country in geriatric population.

METHODOLOGY

The study was a cross-sectional study involving elderly participants of age 65 years and above. After obtaining written informed consent, participants were recruited from Geriatric out-patient department of All India Institute of Medical Sciences, New- Delhi, India. The study participants with any definitive musculoskeletal system morbidity (any degenerative or inflammatory arthropathy and myopathy) and fractures on X-Ray of hip or L-S spine were excluded. We focussed on hip or spine fracture as these are the common site for osteoporotic fracture .Consecutive sampling method was used to recruit the participants during the period January to June 2013. Totally 98 study participants were included in the study.

Evaluation Strategy

Socio-demographic details including age, sex, socio-economic status, marital status, educational qualification and occupation were collected. Detailed history in the preceding 12 months regarding presence of co-morbidities like stroke, hypertension, diabetes, chronic kidney disease, coronary artery disease, benign prostatic hypertrophy, anaemia, osteoarthritis, rheumatoid arthritis, myopathy, polymyositis, chronic obstructive pulmonary disease, bronchial asthma, obvious malignancy and tuberculosis were thoroughly scrutinized. Spirometry analysis for pulmonary function tests was done by Spiro Air (Morgan) .We evaluated lung function to look for COPD, as itis a known precipitant of osteoporosis.

Assessment of Grip Strength

Gripper Gym Dynamometer was used to measure the hand HGS of the study participants. The participants was asked to sit comfortably with shoulder adducted and neutrally rotated, elbow flexed to 90 degrees, forearm and wrist in neutral position. After holding the instrument to fit in the hand comfortably, the subject was asked to squeeze with maximum strength between the ball of the hand and the fingers without using the thumb. HGS was measured in both the dominant and non-dominant hands, three times in each hand. The maximum value was noted for each squeeze and the highest of six attempts was recorded.

BMD Measurement

BMDs of the lumbar spine (L2–4) and right femoral neck, and the distal forearm of non-dominant hand were measured through the dual-energy X-ray absorptiometry (DXA) method using a QDR4500a (Hologic Inc., Bedford, MA, USA) by a single, trained X-ray technician. The in vivo coefficients of variation (CVs) of the BMD measurements were 0.3% for the lumbar spine, 0.6% for the femoral neck and 0.4% for the distal forearm.

Biochemical Parameters

An 8-hour-fasting blood specimen was drawn in the morning at 8 AM. The specimen was immediately/appropriately preserved at 4°C. The serum was obtained within 1 day of collection by centrifugation at 1613×gfor 10 min and stored at −80 °C until biochemical analysis. The serum1, 25-dihydroxyvitaminD (1,25[OH]2D) concentration was determined by radioimmunoassay (IDS Ltd., Boldon, England, UK), which has an inter-assay CV value of 12.8%. Immunological tests (Anti Nuclear Antibody, Rheumatoid Factor and C - Reactive Protein) for suspected patient Of Inflammatory Arthropathy Were Also Done.

Statistical Analysis

The statistical analysis was done in SPSS version 21.0. For continuous outcomes, mean & SD and for categorical outcomes proportions were used. Multivariate linear regression was performed to find association between HGS and other variables. A p value <0.05 was regarded as statistically significant. ROC analysis was done to find accuracy of HGS with bone mineral density of forearm, hip bones and spine.

RESULTS

Among 98 elderly participants 55 (56%) were males and 43 (44%) females, with mean (SD) of 70.22(±7.50) years. (minimum 65 and maximum 90 yrs). Majority, 35(36%) of the study participants were from upper middle socio-economic class according to Revised Kuppuswamy socioeconomic scale class. 71.91% of our patient had osteoporosis. The mean (SD) BMI of the study participants were 22.60 kg/m^2. The mean (SD) Vitamin D-3 level was 18.50(+ 13.09) ng/ml (Vit. D levels >20ng/ml were considered as normal) and mean calcium level of 8.67(+ 0.782) mg/dl. The mean (SD) T-score for spine, hip and forearm were -2.2(+1.92),-2.18(+1.52) and -3.40(+1.43) respectively. The mean (SD) HGS was 18.11(+ 14.17) Kg and mean (SD) albumin and creatinine values of 4.07(+0.65) g/dl and 0.97(+ 0.57) mg/dl respectively. Older age group was found to be significantly associated with lower HGS (P=0.02). Mean HGS was found to be higher in males compared to females (19.78 kg vs 15.98 kg), however this difference was not statistically significant (p=0.18). Females had greater loss of bone mineral density in comparison to the males (P=0.18 in spine, p=0.2623 in hip and p=0.3247 in forearm). (Figure 1) No significant association was found between socioeconomic status and HGS and osteoporosis. Overweight and obese individuals were found to have significantly higher HGS in comparison to those with normal or lower BMI (P=0.0003). (Figure 2) Lower BMI was associated with osteoporosis (P= 0.00 in spine, P=0.01 in hip and P=0.00 in forearm). The serum 25(OH) D concentration had no significant association with HGS (p=0.29) or with osteoporosis (P=0.67 in spine, P=0.67 in hip and P=0.69 in forearm). Poorer renal function, as assessed by creatinine levels was associated with osteoporosis (spine (P=0.00), hip (P=0.02), forearm (P=0.07)). Poorer expiratory function had no relation with HGS (P=0.39) as well as the osteoporosis (P=0.17 in spine, P=0.38 in hip, P=0.57 in forearm) in the individuals.

Table 1: Distribution of Study Participants According to HGS, T Scores and Selected Socio-Demographic Variables (N=98)

S. No.	Variables		Mean HGS	P Value	T Scores					
					Spine	P Value	Hip	P Value	Forearm	P Value
1.	Sex	Male(55)	19.78	0.1826	-2.16	0.2623	-2.02	0.0749	-3.27	0.3247
		Female(43)	15.98		-2.41		-2.38		-3.54	
2.	Socio-economic status	Upper lower(21)	17.8	0.9851	-2.00	0.8846	-2.17	0.4703	-3.16	0.7516
		Lower middle(24)	17.9		-2.45		-2.56		-3.65	
		Upper middle(35)	17.9		-2.44		-1.97		-3.33	
		Upper(18)	19.0		-2.02		-2.11		-3.42	
3.	BMI	<18.5(48)	20.0	0.0003	-2.27	0.0010	-2.06	0.0031	-2.14	0.004
		18.5-24.9(18)	7.4		-3.43		-2.94		-3.21	
		>24.9(32)	21.3		-1.63		-1.97		-1.78	

Independent t test was applied, p value<0.05 is significant

Table 2: Logistic Regression Analysis of Spine T Scores with Selected Variables

S. No.	Variables	Odds Ratio	95% CI	P-Value
1.	Sex Male Female	1 0.137	0.878 to 0.604	0.714
2.	BMI >18.5 <18.5	1 0.030	0.042 to 0.101	0.409
3.	COPD Absent Present	1 0.657	1.658 to 0.343	0.195
4.	Osteoarthritis Absent Present	1 0.430	1.233 to 0.372	0.289
5.	Calcium levels Normal Low	1 0.035	0.495 to 0.426	0.882
6.	Phosphate levels Normal Low	1 0.048	0.060 to 0.157	0.376
7.	Vit D3 levels Normal Low	1 0.004	0.022 to 0.014	0.660
8.	HGS Normal Low HGS	1 0.054	0.027 to 0.082	0.000

Vit D3 >20µg/L, Calcium levels >8mg/L, Phosphate levels >25mg/Lwere set as normal. Cut off for HGS is taken as 15kg (median value)

Table 3: Logistic Regression Analysis of Hip T Scores with Selected Variables

S. No.	Variables	Odds Ratio	95% CI	P-Value
1.	Sex Male Female	1 0.208	0.844 to 0.427	0.516
2.	BMI >18.5 <18.5	1 0.027	0.088 to 0.034	0.384
3.	COPD Absent Present	1 0.879	1.736 to -0.022	0.045
4.	Osteoarthritis Absent Present	1 0.659	1.347 to 0.028	0.060
5.	Calcium levels Normal Low	1 0.388	0.783 to 0.006	0.054
6.	Phosphate levels Normal Low	1 0.030	0.063 to 0.123	0.520
7.	Vit D3 levels Normal Low	1 0.006	0.022 to 0.009	0.437

Table 3: Contd.,

8.	HGS Normal Low HGS	1 0.028	0.004 to 0.051	0.022

Vit. D3 >20µg/L, Calcium levels >8mg/L, Phosphate levels >25mg/Lwere set as normal. Cut off for HGS is taken as 15kg (median)

Table 4: Logistic Regression Analysis of Forearm T Scores with Selected Variables

S. No.	Variables	Odds Ratio	95% CI	P-Value
1.	Sex Male Female	1 0.369	0.924 to 0.186	0.190
2.	BMI >18.5 <18.5	1 0.038	0.015 to 0.092	0.158
3.	COPD Absent Present	1 0.300	0.449 to 1.049	0.427
4.	Osteoarthritis Absent Present	1 0.061	0.540 to 0.661	0.841
5.	Calcium levels Normal Low	1 0.009	0.353 to 0.336	0.961
6.	Phosphate levels Normal Low	1 0.045	0.036 to 0.126	0.268
7.	Vit D3 levels Normal Low	1 0.004	0.010 to 0.017	0.593
8.	HGS Normal Low HGS	1 0.053	0.032to 0.073	0.000

Vit. D3 >20µg/L, Calcium levels >8mg/L, Phosphate levels >25mg/Lwere set as normal. Cut off for HGSwas taken as 15kg (median)

ROC Analysis

ROC analysis showed the area under curve (AUC) for lumbar spine was found to be 0.725 (0.623-0.827), AUC for hip bone 0.724 (0.680-0.869), AUC for forearm bone 0.837 (0.729-.0953)

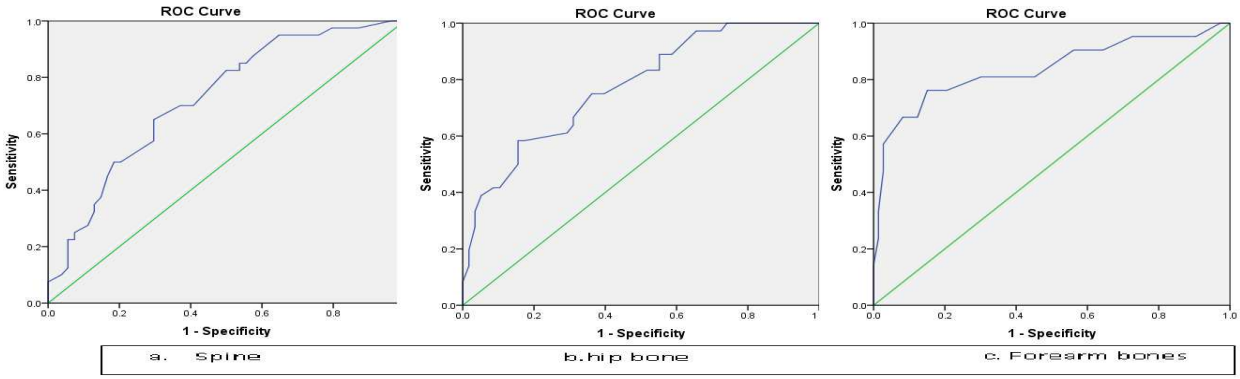

Figure 1: ROC Curves of Grip Strength

It showed that 72% of osteoporosis of spine was explained by HGS(AUC-0.725 (0.623-0.827). Similarly 72% and 83% of osteoporosis in hip and forearm bones were explained by HGS respectively (AUC for hip bone 0.724 (0.680-0.869), AUC for forearm bone 0.837 (0.729-.0953).

DISCUSSIONS

In our study increasing age was associated with osteoporosis supported by the known pathological concept of progressive decline in muscle strength and alteration of organic contends of bone. [13,14]. Similarly female's Indian elders had greater loss of BMD ,probably due to decrease in estrogen levels during post menopausal period. [15, 16] .

Several studies support the hypothesis that vitamin D deficiency impairs muscle function, and thus increases the risk of falls and possibly fractures [17,18] ,but few reported the absence of significant relation of osteoporosis with vitamin D-3 level [19,20].we didn't find any correlation of level of Vit D3 either with the extent of osteoporosis . We did not find any relation between FEV1, serum Vitamin D3 level and osteoporosis, which is in contradiction with the study done by Tadashi Ohara et al [21], found a dose-response relationship between the serum concentration of Vitamin D-3 and FEV1 and also had concluded that COPD itself could be a risk factor for osteoporosis. A plausible explanation to our finding is that our subjects were comparatively healthy with normal lung function.

We noticed HGS decreases significantly with aging and in female sex probably the explanation is simple with aging and in female after menopause there is decrease in muscle strength. Correlation of HGS with nutritional status in the form of BMI was not linear but obese patient had Better HGS. This finding was also similar like other study [22] Similarly relationship of BMI and bone mineral density was not linear. Epidemiological data had mixed results, some suggested high body weight was correlated with high bone mass [23,24], results were dissimilar in other study. [25]

Poor HGS had shown to be most important predictor of osteoporosis in asymptomatic male and female elders as assessed by BMD score of Neck femur, hip and hand even after adjustment of confounding factors like age, BMI, socioeconomic status, blood calcium and vit D. This findings had been supported in most of the epidemiological study [26, 27]. Rikkonen T et al [29] in a pooled sample of 979 Finnish postmenopausal women showed that Muscle strength tests, especially HSG, serve as an independent and useful tool for postmenopausal Osteoporesis risk assessment. Similarly, in a study of males and females above 50 years of age, W. G. Dixon et al [10] showed that in women, low HGS was associated with low bone mineral density at both the spine and hip and an increased risk of incident vertebral fracture. A modest relationship between bone structure and each of physical function and HGS was observed in the study by Andy Kin On Wong et al. [30] .

We tried further to establish the accuracy of HGS in predicting or diagnosing osteoporosis in asymptomatic Indian elders .ROC analysis showed the usefulness of HGS up to 83% in diagnosing osteoporosis. Thus our study findings suggest HGS as an alternative measure in diagnosing/screening osteoporosis in geriatric population, especially in resource limited settings. This findings is really interesting as primary care physician, even paramedics, by assessing HGS with simple hand dynamometer can predict about bone health and give recommendation accordingly to prevent future osteoporetic fracture and its further consequences. This consequently results in a reduction of heath related expenses as well as socio-economic complications.

Strengths and Limitation

To best of our knowledge it was the first effort in Indian elderly population to find out the accuracy of poor HGS in diagnosis of osteoporosis. .However the study had limitation of small sample size.

CONCLUSIONS

Poor HGS was an independent predictor of osteoporosis in elderly cohort attending geriatric OPD. We suggest poor HGS could be practical and cheaper screening/diagnostic test for osteoporosis in resource limited settings .We also stressed the need of further studies in multiple cluster to strengthen the findings of present study.

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